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Forestry Research West

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September 1997

A report for land managers on recent developments in forestry research at the three western Experiment Stations of the Forest Service, U.S. Department of Agriculture.

Forestry Research West

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Cover

Wildlife viability and fish habitat were two of the key issues that researchers focused on in helping develop the forest plan for the Tongass National Forest in Alaska. Read more about the plan and involvement of Forest Service scientists, beginning on page 3.

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We're Listening!

Thank you to all "Forestry Research West" readers who responded to our recent survey. We received over 500 responses. Intent of the survey was to solicit suggestions for improving the magazine's design and content, get a feel for how readers use it, which sections are most important, and to see if there is an interest in receiving it through the Internet.

Most readers like the magazine for ease of reading, broad subject range, ease of ordering publications, the balance and variety of feature articles, and the multidisciplinary approach.

While most like the publication the way it is, a few suggested changes include: longer articles, more issues per year, include scientist profiles, more abstracts, more photos, less expensive paper, use color, more publication reviews, and list announcements of upcoming symposia and workshops.

Most readers like the design as it is, complementing the use of white space and graphics. Some respondents requested shorter articles, some longer articles, better writing, more graphics, annual index of articles, eliminate bureaucratic talk, and a different color of ink.

The top five topics requested for future issues were (in order of interest): wildlife/habitat and interactions; silviculture/ regeneration/tree improvement; recreation/ tourism; wild and prescribed fires; and range/grazing/ livestock. Other topics that rated high were: riparian/ fisheries; hydrology/ watersheds/erosion; forest pests; and reforestation/ vegetation restoration.

Readers, for the most part, like the feature articles as they are, citing conciseness, well-written, and well-balanced. Dislikes include: too long, too technical, not balanced enough, too short, and not enough detail.

About half the readers find two or three issues per year contain articles that have direct value to them; the other half find all four issues of direct value.

The overwhelming majority think the writing is concise and clear. About 37 percent read all of each issue; the remainder scan for items of interest. Approximately 50 percent find the feature articles of most interest; 50 percent prefer the "New from Research" section.

The vast majority of readers use the publication ordering cards and understand the ordering instructions. Several suggestions were offered to facilitate the ordering of publications, including: using the Internet and faxes; self-gummed labels for ordering cards; a central clearing house for other Forest Service publications; and toll-free numbers.

"Forestry Research West" is issued quarterly, and most readers prefer no change; about 20 percent would like to see it more frequently.

Fifty-seven percent of readers keep back issues of the magazine, with the majority using them in a reference/ library capacity. Nearly 70 percent route issues to others within their office or organization.

Fifty-six percent of readers have interest in seeing "Forestry Research West" on the Internet; however, most of those would also like to continue to receive hardcopy by mail.

While the survey shows that readers are generally pleased with "Forestry Research West" the way it is, the producers and contributors to the magazine are working on an on-going basis to make sure it is the best publication it can possibly be.

Over the next few months, we will be working to incorporate as many of your suggestions as possible. We are also exploring the possibility of putting the magazine on the Internet. As with many products from government agencies, we are limited by shrinking budgets and staff, and federal guidelines such as those of the Government Printing Office.

Thank you again to all who responded to our questionnaire. Comments on the magazine are always welcome. Write to us at: Forestry Research West, USDA Forest Service, 240 West Prospect Rd., Fort Collins, CO 80526, or phone (970) 498-1324, Fax: (970) 498-1010.

In the next issue of "Forestry Research West", we'll provide a summary of the national Forest Service Customer Survey, conducted to see how the Agency is responding to the needs of its publics. Stay tuned.

Tongass Management Plan: Research Played a Key Role

by Sherri Richardson, Pacific Northwest Research Station

The Tongass National Forest in Alaska is one of the Nation's largest National Forests at 17 million acres. The long-awaited forest plan for the Tongass was finalized in May 1997. The recently approved 10-year plan was a long time coming against a highly charged political, economic, and environmental landscape. But the development of the plan also had a unique structure: it was the first time science was invited to directly participate as part of the forest planning team.

Six senior scientists from the PNW Research Station were incorporated directly into the planning team. They were Douglas Swanston, a research geologist and coleader of the Tongass Land Management Team; Charles Shaw, a research plant pathologist and science manager for the team; Winston Smith, a research wildlife biologist; Kent Julin, a research ecologist; Guy Cellier, a research geographer; and Fred Everest, a research fisheries biologist and research policy coordinator for the team.

An adult goshawk surveys the area.

"The PNW scientists joined the planning team in 1995 as full members but maintained distinct and separate roles from the National Forest System members to assure that credible scientific information was used," explained Douglas Swanston. "We were asked to analyze, assemble, and interpret available scientific information on the resources of the Tongass and make that information available to National Forest decisionmakers for development of the plan."

The scientists focused their efforts on five key issues critical to management of the Tongass:

- wildlife viability
- fish habitat
- cave and karst resources
- social and economic concerns
- alternatives to clearcut timber harvesting

The PNW scientists, with assistance from more than 50 resource specialists and scientists from other Federal and state agencies and universities collected, analyzed, and interpreted the most current scientific information on these key issues. This information was provided to managers responsible for deciding the content and direction of the Tongass plan. Managers then used the scientific information, along with legal mandates, public desires, and other factors, to reach final land management decisions. Scientists did not make any of these decisions. In a check of the plan, the scientists found the decisions highly consistent with the scientific information they provided the forest managers.

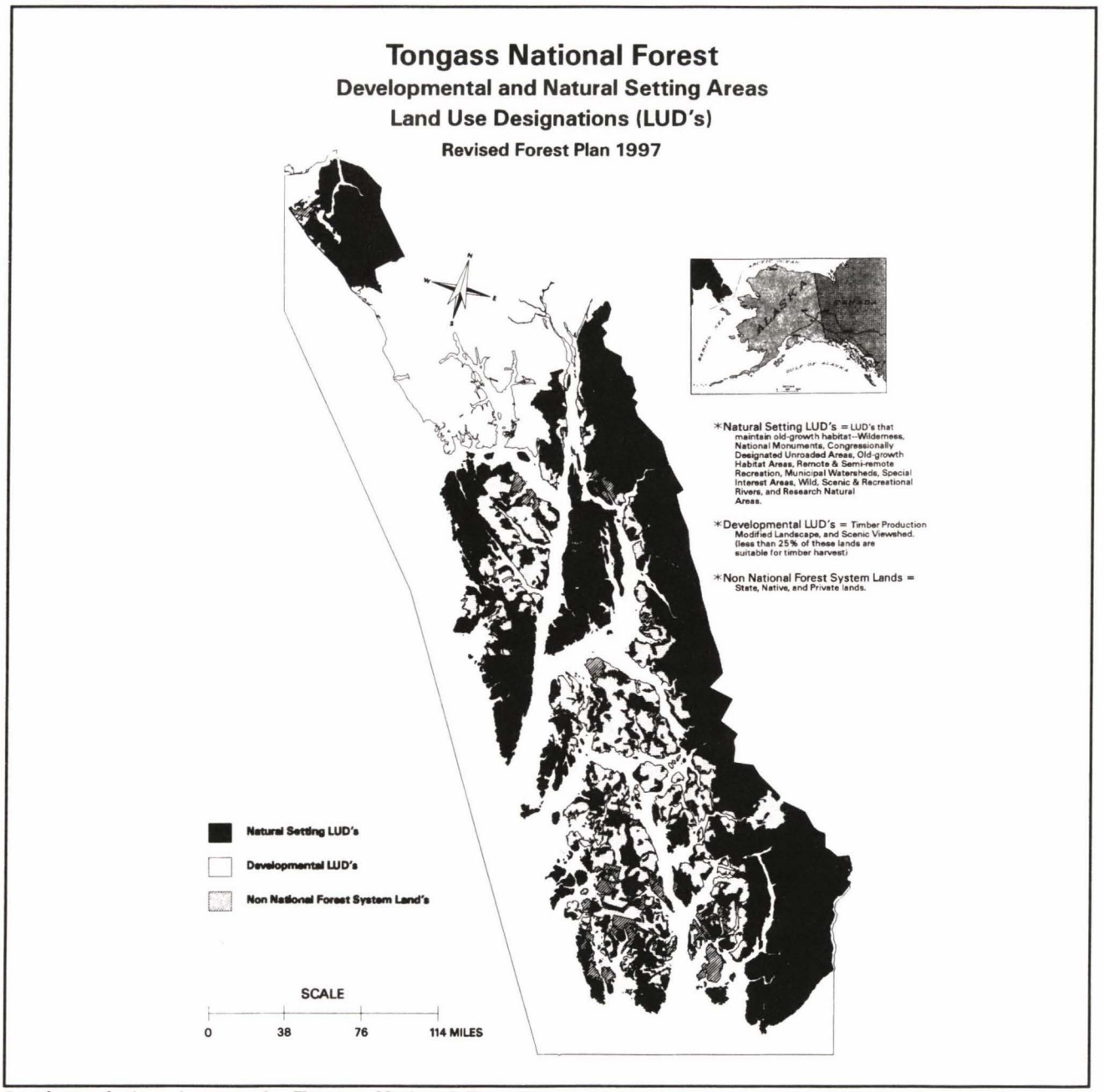
Key Findings

Examples of key science findings developed by PNW scientists and used in the plan are:

The amount and connectivity of the high-volume old growth strongly influences the likelihood that a broad range of old-growth associated wildlife species will continue to persist in the future across the Tongass.

Old-growth reserves appropriately spaced and stratified across the Forest are one approach to maintaining viable wildlife populations. About 16 percent of the high-volume old growth outside of legislative withdrawals in the Tongass National Forest has already been harvested. Past harvest has been spatially clumped with concentrated activity at lower elevations on islands such as Prince of Wales, Kosciusko, Zarembo, and northeast Chichagof.

Reserves of remaining old growth by themselves do not appear to maintain interconnected, functionally interrelated old-growth ecosystems. Wide beach and estuary fringes and uncut riparian buffers enhance connectivity among these otherwise isolated old-growth blocks by providing elevational and horizontal corridors. Wide beach fringes also provide important habitat for bald eagle and goshawks owing to increased screening from management disturbance and increased prey diversity and abundance.


Tongass National Forest
Developmental and Natural Setting Areas
Land Use Designations (LUD's)
Revised Forest Plan 1997
*Natural Setting LUD's = LUD's that maintain old-growth habitat--Wilderness, National Monuments, Congressionally Designated Unroaded Areas, Old-growth Habitat Areas, Remote & Semi-remote Recreation, Municipal Watersheds, Special Interest Areas, Wild, Scenic & Recreational Rivers, and Research Natural Areas.
*Developmental LUD's = Timber Production Modified Landscape, and Scenic Viewshed. (less than 25% of these lands are suitable for timber harvest)
*Non National Forest System Lands = State, Native, and Private lands.
Natural Setting LUD's
Developmental LUD's
Non National Forest System Land's
SCALE
0
38
76
114 MILES

Land use designations on the Tongass National Forest.

Productivity of the fisheries resources of the Tongass is dependent on protecting spawning and rearing habitat, assuring that temperature and sediment levels are not elevated significantly above natural variation, and assuring a source of large woody debris for the future.

Habitat productivity for fish can be maintained by retaining protective timber buffers along riparian areas and associated tributary channel systems; and by eliminating management activities in headwater areas that might accelerate landslides that result in sediment and large woody debris going into anadromous fish streams.

World-class karst and cave landscapes on the Tongass underlie about 437,000 acres of forested and alpine terrain in a northwest trending belt of carbonate rocks extending from Dall and Prince of Wales Islands to Chichagof Island.

These karst and cave landscapes are formed from sea level to the tops of some of the highest peaks in the Alexander Archipelago. Some of the most highly developed karst and cave terrain, the most fragile and sensitive to management disturbance, is concentrated in the alpine and subalpine zones and on slopes greater than 70 percent. At lower elevations within the forest zone, about 30 to 50 percent of the karst terrain in the Ketchikan Area and 10 to 20 percent in the Chatham and Stikine Areas are believed to be highly sensitive to human disturbance.

As a whole, the regional economy of southeast Alaska has both strengths and weaknesses compared to the economy of the entire United States.

Annual increases in employment opportunities (2.1 percent annually from 1985 to 1994) are higher in southeast Alaska than in much of the rest of the country (1.5 percent annual growth), as is population growth (1.6 percent in southeast Alaska compared to 1 percent nationally). Real average earnings per job, however, have declined at a rate of 1.5 percent annually since 1985, and economic diversity as measured at the borough level also is lower than the average measured at the county level in the rest of the United States. Any impacts to employment should be viewed within these existing trends.

Science Used in Planning

"Senior scientists provided decisionmakers with comprehensive assessments of natural resource conditions, trends, and risks associated with management of the Tongass," said Tom Mills, Director of the PNW Research Station. "Credibility of the published science information was assured by independent scientific reviews. Land managers used the science information to build

alternative scenarios for long-term management of resources for the Tongass, and the scientists estimated the consequences of these alternative scenarios."

The Next Step

"Forest Service scientists working jointly with their counterparts in the state of Alaska and other Federal agencies have initiated a series of studies to assist managers in implementing the Tongass Land Management Plan," explained Swanston. Research is planned for the next 5 years to address high-priority information needs generated by the planning process. These include many of the natural resources of the Tongass, (e.g., wildlife habitat, timber growth and yield, fish stream attributes) economic changes in southeast Alaska, and alternative methods for timber harvesting.

For More Information

The following assessments are now available. (See ordering cards near the back of this issue).

The Alexander Archipelago Wolf: A Conservation Assessment (PNW-GTR-384)

Karst Landscapes and Associated Resources: A Resource Assessment (PNW-GTR-383)

Conservation Assessment for the Northern Goshawk in Southeast Alaska (PNW-GTR-387)

A Conservation Assessment for the Marbled Murrelet in Southeast Alaska (PNW-GTR-388)

Assessments of Wildlife Viability, Old-Growth Timber Volume Estimates, Forested Wetlands, and Slope Stability (PNW-GTR-392)

Scientific Information and the Tongass Land Management Plan: Key Findings from the Scientific Literature, Species Assessments, Resource Analyses, Workshops, and Risk Assessment Panels (PNW-GTR-386)

Forthcoming:

Wind Disturbance Assessment

Socioeconomic Trends and Conditions in Southeast Alaska Communities

Evaluation of Use of Scientific Information for the Tongass Forest Plan Final Alternative

Timber Demand Projections for Alaska

The Use of Risk Assessment Ponds in the Tongass Planning Effort

Colorado's Forest Insects

by John Schmid, Steve Mata, and Rick Fletcher, Rocky Mountain Research Station

The natural variability of forest insect populations is frequently needed in reports for forest plans because certain insects cause major disturbances in forests. They affect tree growth, stand structure, species composition, fire hazard, nutrient cycling, and decomposition of woody material. Although a multitude of insects dwell in Colorado forests, it is primarily specific bark beetles and defoliators that significantly affect tree growth and survival and thus receive the most attention.

Insects populations are usually classified as either endemic or epidemic. Endemic populations are low, relatively static numbers of an insect that cause essentially unnoticed or insignificant amounts of defoliation or tree killing. They represent the smallest population level. Epidemic populations are high, fluctuating numbers that cause readily noticed or significant amounts of defoliation or tree killing.

Entomologist John Schmid (retired) and Forestry Technician Steve Mata, Rocky Mountain Research Station, have compiled a report on common forest pests of Colorado. Their information comes from various publications, notes, and unpublished reports. Following is a brief summary of their report:

Mountain Pine Beetle

The mountain pine beetle (*Dendroctonus ponderosae* Hopkins), MPB, is a native bark beetle (Coleoptera: Scolytidae) that attacks and infests primarily ponderosa pine and lodgepole pine. In ponderosa pine, the MPB usually infests standing live trees >8 inches dbh, but may attack trees <8 inches when such trees are intermingled with larger trees. In lodgepole pine, the MPB attacks larger diameter trees, but may also attack smaller trees when they are intermixed with the larger trees.

During the initial stages of epidemics, trees are usually killed in small groups of 3-10 trees. As the population increases, such groups may coalesce into one large group of more than 100 dead trees. Endemic MPB poulations are usually associated with single trees that are lightning-struck or diseased, cohabiting therin with other scolytids such as *Ips*.

The first trees attacked by the MPB become focus trees that attract subsequently emerging beetles. As MPB attacks fill the intial tree, later arrivals attack adjacent trees and thus create a group of infested trees. The MPB influences stand structure in pure pine stands by killing greater proportions of large diameter trees, so the average stand diameter is lowered during epidemics.

"MPB epidemics also influence herbage production, wildlife populations, and fire hazard," says Schmid. "The growth of forbs, sedges, and grasses increases in beetle-killed areas. Wild ungulates may benefit from the increased herbaceous production, and the standing beetle-killed trees may provide habitat for cavity-nesting birds."

MPB populations have ranged from endemic to epidemic in ponderosa and lodgepole pine stands in Colorado. The frequency of epidemics in a given area of lodgepole pine seems to range from 20 to 40 years, depending on how rapidly some trees grow into large diameter categories. Frequency in ponderosa pine stands range from 50 to 100 years, depending on how much of the original stand was beetle-killed.

The duration of epidemics can vary due to unpredictable weather factors that may cause rapid declines in MPB populations. An epidemic may last several years in a particular stand, whereas the epidemic as part of a drainage may last for 10 years or more. Average duration of MPB epidemics in lodgepole pine is 6 years; for ponderosa pine, epidemics last 2-5 years, with long-term outbreaks lasting 7-14 years.

MPB populations as of 1994 were at endemic levels in most national forests of Colorado, and were thus in the lower portion of their population range for this region. The authors believe if current fire suppression policies are continued and silvicultural activities are minimized in the pine types for the MPB, stands will become more conducive for MPB epidemics.

Spruce Beetle

The spruce beetle (*Dendroctonus rufipennis* Kirby), SB, is a native bark beetle that attacks and infests primarily Engelmann spruce in Colorado. The SB generally infests wind-thrown or downed trees. Endemic SB populations develop to epidemic proportions and can spread to standing trees when sufficient wind-thrown trees are not available to absorb the subsequent population. Epidemics are most common in overmature stands (>24-inch dbh) but may be sustained in large pole and immature stands.

Because endemic SB populations normally reside in wind-thrown spruce, they do not noticeably change stand structure and species composition. In contrast, epidemic SB populations can drastically alter stand structure and species composition. Epidemics influence tree-water relationships such as interception and transpiration,

and if the epidemic is large enough, streamflow. The death of overstory spruce greatly reduces interception of precipitation by the canopy, and thus allows precipitation to reach the forest floor. Similarly, the death of overstory spruce also removes them as sources of transpiration for the ecosystem.

Forage production in beetle-killed stands is much greater than in green stands. Grasses and sedges showed increased density in beetle-killed stands. Forbs were 2.3 times more numerous, but browse plants decreased. In general, the greatest density, number of species, and index of occurrence of plants were found in beetle-killed stands.

Schmid says that SB epidemics can also influence both fire hazard and fire intensity. Increased fire hazard created by the killing of spruce by beetles is limited to the first two years after beetle attack when the dead and dying needles increase the fine fuel component," he says. "Once these fuels fall from the dead trees, fire hazard is essentially the same as before the trees were attacked. In contrast, fire intensity increases after SB infestation and remains at a higher level for decades because of the increased dead fuel loads that don't readily decay."

The frequency of SB epidemics depends on the size of the area being considered, the extent of the SB-caused tree mortality and its' modification of stand structure in the stand, and how fast the stand grows into the hazardous condition. The frequency of epidemics in a particular stand is generally much less than that for an area composed of many susceptible and nonsusceptible stands.

SB populations as of 1994 were at endemic levels in the spruce-fir forests of Colorado. "If silvicultural activities are minimized, stands will become more conducive for SB epidemics," says Schmid.

Douglas-fir Beetle

The Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopkins), DFB, is a native bark beetle that attacks Douglas-fir. Endemic populations in Colorado usually infest wind-thrown, physically damaged, or diseased trees. DFB epidemics in Colorado have arisen during, and expanded following, western spruce budworm epidemics. The DFB attacks standing trees with dbh ranging from 8-24 inches in Colorado. Tree mortality during epidemics ranges from scattered single trees to groups of 100 or more. Tree mortality during the 1980's epidemic in Colorado ranged from scattered trees to small groups, and reflected the distribution of the susceptible-size trees.

"Beyond tree mortality, data are generally lacking with respect to the influence of DFB infestations on forage, big game, and other animal populations, and water resources," says Schmid. "Presumably, these effects would be similar, but of a lesser magnitude, than MPB or SB infestations. Continued suppression of fires and cessation of silvicultural activities enhance conditions for DFB outbreaks in Colorado."

Western Tent Caterpillar

The western tent caterpillar [*Malacosoma californicum* (Packard)], WTC, is a native tent caterpillar that defoliates primarily aspen above 8,000 feet. This caterpillar also feeds on cottonwood and chokecherry at lower elevations. WTC consume apsen leaves in the spring. Leaves on trees of all sizes may be consumed when the WTC is epidemic. The larvae may emigrate from completely defoliated trees and consume foliage on typically nonhost plants during the process.

"Endemic and epidemic WTC populations cause disproportionate effects on individual aspen growth and survival," says Schmid. "Endemic populations cause partial defoliation that probably results in negligible growth loss and rarely in tree death. In contrast, defoliation by epidemic WTC populations causes growth loss in defoliated trees; and complete defoliation for several consecutive years increases tree mortality."

Trees may refoliate after the first defoliation, but continued defoliation reduces the trees' capacity to refoliate in successive years. Complete defoliation for one year does not usually cause significant changes in stand structure. However, if defoliation causes the death of the overstory trees as described previously, then the stand may revert to an early age class, or in the presence of seedlings and saplings of a shade tolerant species such as white fir or subalpine fir, succeed to a spruce-fir stand.

Schmid says that WTC populations as of 1994 were at endemic levels in aspen forests in Colorado. "Stand structure does not influence the start of WTC epidemics, so the lack of silvicultural activity and the continuation of fire suppression will not create stands more conducive to epidemics," he says.

Pandora Moth

The pandora moth (*Coloradia pandora* Blake), PM, is a native moth that defoliates ponderosa and lodgepole pines in Colorado. The larvae eat needles on trees of all sizes. They generally consume needles 1 or more years old because most feeding occurs in the spring and early summer before the new growth flushes. Because the new growth is not usually eaten, trees commonly have a flush of growth at the tips of the branches the year they are defoliated. In addition, the PM has a 2-year cycle, so most of the defoliation occurs every other year. PM defoliation during epidemics reduces tree growth and can cause tree mortality.

Time intervals between epidemics are estimated to be about 20-30 years in Colorado. Only one epidemic in Colorado has affected more than 500 acres and lasted for several generations. Most PM epidemics last 6-8 years or 3-4 generations.

PM populations in Colorado as of 1994 were at endemic levels. The authors believe that stand density and structure do not influence the start of PM epidemics so the lack of silvicultural activity and the continuation of fire suppression will not create stands more conducive to epidemics.

Western Spruce Budworm

The western spruce budworm is a native moth (*Lepidoptera:* Tortricidae), WSBW, that defoliates primarily Douglas-fir and white fir in Colorado. Less preferred hosts are Engelmann spruce and subalpine fir. WSBW larvae feed on cones, seeds, vegetation and reproductive buds, and foliage. The current year's foliage is usually consumed before older foliage is consumed. Foliage on trees of all sizes is consumed during epidemics. Larval numbers are so prodigious during epidemics that their simultaneous feeding on the various parts of the tree affects tree growth and survival, whereas larval feeding by endemic populations has minute effects.

WSBW defoliation during epidemics reduces radial growth, and extensive defoliation for successive years can cause tree mortality. Mortality can occur after 4 years of >40 percent defoliation per year, and the number of dying trees increases dramatically with additional years of moderate defoliation. Although defoliation alone can cause tree mortality, the defoliation may also indirectly kill trees by predisposing them to subsequent attack by DFB.

"Epidemics alter stand structure," says Schmid. "In unmanaged multistoried stands, epidemics may reduce the seedling and sapling component as well as suppressed and intermediate trees in the canopy. If suppressed and intermediate trees are killed, average stand diameter increases while basal area decreases."

Elk and deer populations may benefit from the increase in forage beneath defoliated stands as they apparently do in SB-killed stands, but the loss of hiding and thermal cover may be detrimental. A number of avian and invertebrate species prey on different stages of the WSBW, along with arachnids and ants.

The frequency of WSBW epidemics in Colorado varies from approximately 20 to 33 years. Populations were generally at endemic levels throughout Colorado as of 1994. "If current fire suppression policies are continued and silvicultural activities are minimized," says Schmid, "stands will become more conducive for WSBW epidemics." Because mutistoried stands provide more substrate for dispersing larvae than single storied stands, such stands enhance WSBW survival and the potential for outbreaks.

Q's and A's

In Colorado, populations of the WSBW and SB reached epidemic proportions prior to 1875 or, in essence, before extensive settlement. Between 1875 and 1910, but as late as the 1940's for the SB, populations of the MPB, SB and WSBW reached epidemic status. Although settler populations increased substantially during this period, fire suppression efforts had not reached the point where the epidemics might be attributed in part to human prevention of natural forest fires. Thus, epidemics were part of the natural variation for MPB, SB, and WSBW populations before settlement and, probably, for DFB, WTC, and PM populations also.

So, will insect epidemics be a part of future forests? Schmid believes they will, "but it depends on the species and management of the forest involved," he says. "MPB, SB, and possibly DFB and WSBW epidemics could be prevented or minimized by good silviculture."

Will epidemics be more frequent? "Perhaps, but not necessarily," says Schmid. "Wilderness and natural areas, parks, or any forested units where silvicultural activities are restricted or prohibited could experience epidemics at frequencies and magnitudes corresponding to presettlement epidemics."

Could future epidemics cause changes in stand structure and density on a unit area basis (per acre) not evident during presettlement or recent epidemics? The authors say this is unlikely because the gamut of stand changes has been experienced.

Could future epidemics cause changes in stand structure and density on a landscape basis unparalleled by past epidemics? Both believe "yes", in some cases.

"Because of fire suppression, stand density and structure has changed significantly over the past 75 years, particularly in montane forests. More recently, silvicultural activities in some national forests have been reduced as management objectives and priorities have changed. This will also contribute to future increases in stand density and vertical structure. Such stand changes in pine and Douglas-fir forests creates highly hazardous conditions conducive for MPB, DFB, and WSBW epidemics over extensive areas. These conditions create the potential for epidemic magnitudes probably not present during presettlement epidemics. However, it should be remembered that epidemics have varying life spans. In order to exceed levels of tree mortality or defoliation evident in past epidemics, an epidemic would have to sustain itself for the maximum number of years," they say.

Further details are in *Natural Variability of Specific Forest Insect Populations and Their Associated Effects in Colorado*, General Technical Report RM-275. Copies are available from the Rocky Mountain Station - Fort Collins. Supplies are limited.

Kings River Sustainable Forest Ecosystem Project

By The Kings River Team and Connie Gill, Pacific Southwest Station

Dinkey Creek watershed, south view.

The USDA Forest Service has an important mission to balance the multiple uses of its lands in an ecologically sustainable way. The challenge is significant for National Forests in the Sierra Nevada, especially with recent controversies over the effects of even-aged timber harvest on old-growth forests and their associated wildlife, such as California spotted owls. Loss of stands with closed canopies, very old trees, large snags and downed wood, and several structural layers is a primary concern. These forest components are needed for the owl and many other wildlife species. Several of these attributes are also believed to be vital for sustaining healthy forests.

To determine whether forested ecosystems can be managed to maintain essential components and still support a variety of uses, management specialists on the Sierra National Forest (SNF) have teamed up with scientists from the Pacific Southwest Research Station (PSW) in an adaptive management study on the Kings River Ranger District, in the southern Sierra Nevada.

The project, initiated in 1994, grew from concern about the status of the California spotted owl. A 1992 technical assessment of the owl led to a Regional Environmental Assessment (EA) that amended the Land and Resource Management Plans (LRMPs) of all national forests in the western Sierra Nevada. It was evident from the EA that new directions were needed for managing national forest lands in the Sierra Nevada, not just for the owl, but for multiple resources and values.

Two adjacent watersheds—Big Creek and Dinkey Creek—each covering about 32,000 acres, have been dedicated to the project. In past decades, considerable timber harvest has taken place on both watersheds. Today, they are primarily forested with mixed-conifer, ponderosa pine, and hardwoods.

Management emphasis on the Big Creek watershed is uneven-aged, small-group selection, with a 200-year rotation (0.5% of the land area being harvested each year). Primary goals are to mimic pre-1850 fire regimes, to promote continuous forest cover, to retain older vegetation in riparian areas, to leave large trees on half of the landbase capable of growing them, and to establish stream-side management zones that will maintain and enhance riparian values.

In the second watershed, Dinkey Creek, a three-tiered landscape approach will be implemented. Primary goals in the bottom tier (riparian zone—20% of landbase) are to retain older vegetation, to recruit large woody debris and large trees, to treat fuels with low-intensity burning, to salvage catastrophic mortality but retain individual mortality, and to establish ecological unit boundaries.

Primary goals in the middle tier (50% of landbase) are to manage for a moderately dense forest with medium to large trees, to maintain 40% canopy closure of young and older vegetation, to use uneven-aged management prescriptions, to salvage individual and catastrophic mortality, to meet snag and downed wood requirements for wildlife, and to use fuel treatments together with silvicultural treatments.

Primary goals in the upper tier (30% of landbase) are to retain 30-40% canopy closure, to achieve wide spacing among the medium-sized and large trees, to maintain or create an understory of grasses, annual forbs, and low shrubs, and to underburn to maintain defensible fuel conditions.

The two management systems will be implemented in conjunction with ongoing studies by scientists from the PSW Station and various university cooperators. Three PSW research units are presently involved, one each from Fresno, Albany, and Redding.

"Those of us involved in the project are very excited about its potential," says Jared Verner, Science Team Leader for the project. "It's generated considerable interest within both the management and research arms of the Forest Service, among various academic cooperators, and in the general public. In the short-term, it will result in many publications about the effects of management actions on components, processes, and their interactions in forest ecosystems in the southern Sierra Nevada. In the long-term - on the order of 50 years or longer - it should begin to show us whether either or both of the management strategies have the potential to maintain all key ecosystem resources, while allowing commodity extraction and other human uses of the forest." The following summarizes current progress on these studies:

Demography of the California Spotted Owl

The California spotted owl in the western Sierra Nevada is closely associated with dense forests and woodlands. In Sierran conifer forests, nesting and roosting sites are typically in old stands with large trees and snags. Home ranges of pairs averaged about 3,500 acres during the breeding period and about 10,000 acres during the nonbreeding period.

Big Creek, showing sand deposits.

Underway since 1990, the study covers an area of 250 square miles in the Sierra National Forest and 130 square miles in Sequoia/Kings Canyon National Parks. In each study area, all territorial birds are located, captured, and color-banded. Annually, all of these owls are relocated and their breeding/nonbreeding status is monitored. All young produced are color-banded. Results enable researchers to estimate population trends and note owl responses to various factors, such as timber sales and annual variation in climate. Near-term objectives of the study include estimating owl densities, occupancy of territories, turnover rates, vital rates, and site fidelity among pairs and individual spotted owls. The main long-term objective is to determine whether one or both of the landscape treatments in the Kings River Project Area create habitat in which owls can maintain a self-sustaining population.

Preliminary estimates of population trends calculated from 1988 through 1996 indicate statistically significant declines of 7% in the Sierra National Forest and 5% in Sequoia/Kings Canyon National Parks. Because the undocumented movement of territorial owls beyond study area boundaries can negatively bias the estimates of population trend, scientists continue to view these results with caution.

Diets of the California spotted Owl

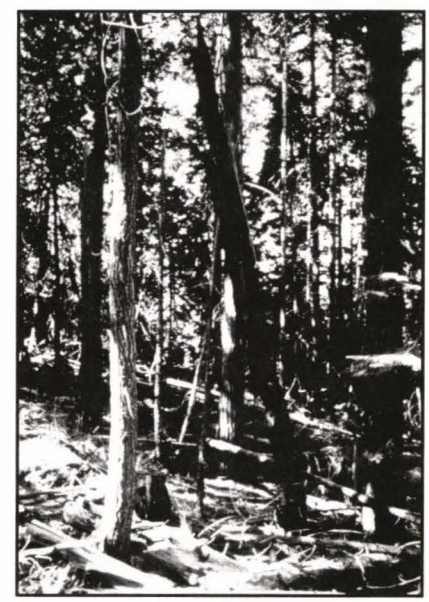
Knowing the prey of the California spotted owl will help to evaluate proposed management plans that could affect the prey base, and thus affect the owls.
Owls regurgitate the less digestible portions of consumed prey (bones, feathers, exoskeletons, fur) in formed pellets. Pellet contents

were examined to identify the species of prey taken by the owls. In oak woodland and riparian deciduous habitats, 20 prey species were identified. The dusky-footed woodrat comprised about 80% of the prey biomass taken by the owls in these lower-elevation habitats. Pocket gophers made up 11% of the biomass, followed by mice, birds (including scrub jays and other small owls) and a variety of small mammals. In higher-elevation conifer sites, 35 prey species were identified from owl pellets. Flying squirrels were predominant, accounting for 51% of the biomass, followed by pocket gophers, birds (including Steller's jays, northern flickers, and western screech owls), mice, and other small mammals.

Weather and Nest-site Structure Associated With California Spotted Owl Reproduction

Because factors that influence reproductive success of the owls are still unclear, this study is exploring weather variables, forest structure, and owl reproductive success at more than 100 nest sites used from 1990 through 1997 in the Sierra National Forest and Sequoia/Kings Canyon National Parks study areas. Monthly means for maximum and minimum temperatures, precipitation, and wind speed were recorded. Stand structure was measured around nest sites, including canopy cover and height-specific crown volumes for all trees.

Preliminary results suggest that wet springs may directly reduce reproductive success or have an indirect effect, such as reducing the abundance of prey. High foliage volume above nests may favorably influence the microclimate at the nest, buffering owl pairs or fledglings from weather-related stress.



Existing condition - heavy fuel load.

Desired condition. Park-like with clean forest floor.

Variations in the Abundance and Productivity of Forest Birds

Initiated in 1994, the objectives of this study are to learn whether individual species of breeding birds shift up and down in elevation in response to the severity of the previous winter's weather, and to determine whether their breeding success is related to specific habitat attributes and changes in habitat. Hundreds of nests of forest songbirds have now been located and monitored in four forest types—ponderosa pine, mixed-conifer, true fir, and lodgepole pine—ranging in elevation from about 4000 to 9000 feet.

In sink habitats, reproduction is inadequate to maintain local population levels and populations are maintained only through immigration from nearby source populations. Researchers are examining elevational shifts in abundance, especially as they relate to weather conditions such as annual precipitation levels, peak snowfall, and temperature. Birds move upslope or downslope between years in response to wet or dry winters. We need to know whether variations in productivity of the birds are associated with these shifts. Do optimal habitats change with variation in winter severity? And do birds accurately evaluate productive habitats and, accordingly, make appropriate decisions about where to settle? Preliminary data suggest that this may be the case, at least for some bird species.

Ecology and Population Dynamics of Small Mammals in Forested Ecosystems

Begun in 1994, the objectives of this study are to characterize annual variations in relative abundance of various species of small mammals, to relate this information to the occurrence and breeding activities of spotted owls, and to understand the population dynamics of the more

abundant species of small mammals. Because dusky-footed woodrats are a major source of food for California spotted owls, study of their habitat relations is an important component of the Kings River Project.

Small mammal populations in the oak woodlands studied to date are dominated by brush mice, California mice, and dusky-footed woodrats. Dusky-footed woodrats are most effectively captured in traps set near their "house," either on the ground or in adjacent trees. The "houses" typically are incorporated into large piles of sticks. Although woodrats in these oak woodlands do not use "stick-houses," many of their "houses" are in holes in trees or in rockpiles with only a small scatter of sticks to indicate use by woodrats. Currently, woodrats are being monitored during their activity periods to gain a better understanding of their home ranges on the ground and in the trees. Future small mammal work will concentrate on species such as flying squirrels and chipmunks that are associated with mixed-conifer forests at higher-elevations.

Occurrence and Distribution of Martens and Fishers

The Dinkey Creek Watershed includes a very large furbearer management area, but information about the status of these mammals in the watershed was unknown at the time the management area was designated. Intensive track-plate studies in both watersheds of the Kings River Project have now documented the presence of both martens and fishers, with the martens occurring at higher elevations (generally above 5000 feet) and fishers at lower elevations. These studies are currently on hold, pending acquisition of sufficient funds to continue them.

Seasonal and Annual Truffle Abundance in Southern Sierra Nevada Forests

This study is important because several species of small mammals rely on truffles for a substantial portion of their diet, and most of these species, in turn, are an important source of food for higher predators, such as California spotted owls. Although much research has been devoted to habitat requirements of the spotted owl, fundamental work is still needed on how truffle abundance changes with forest conditions to determine how truffle availability may influence prey base populations of small mammals.

Three new species of truffles have been identified during this study. Data indicate that truffles in general are scarce year-round in blue oak woodlands and red fir forests. Their greatest abundance occurs in ponderosa pine forests, where truffle biomass is consistently high year-round. Truffles are seasonally abundant for two months in early summer in mixed-conifer forests. The initial patterns in truffle abundance may explain some of the differences between forest types in the abundance of small mammals and the higher carnivores, which prey on fungal consumers.

Structure and Function of Ectomycorrhizal (EM) Fungal Communities

Pines and oaks have an absolute requirement for a mutualistic association between their roots and fungi—the so-called ectomycorrhizal fungi. This mutualism is necessary for the trees because they obtain their mineral nutrients, such as phosphorous and nitrogen, from the fungi. In return, the fungi obtain energy in the form of simple sugars from the trees. Little is known of the fungal species involved and how they differ in terms of their benefit to the trees, or their roles in the ecosystem. "We do know that one group of these fungi—the truffles and false-truffles—are crucial components of the forest's food web," says Tom Bruns, Research Scientist. "They serve as the major food for many rodents, which are the primary prey of such predadors as owls, hawks, weasels, martens, and fishers. In particular, truffles are the primary food of flying squirrels in Sierran conifer forests, and the squirrels are the primary prey of spotted owls."

Three projects are underway in this study. The first will produce a simple species list of the EM fungi that produce fruiting bodies, such as mushrooms and false-truffles. Already this work has produced some new or rare species. The second is investigating the fungi associated with snow plant (Sarcodes sanguinea), a parasite on the fungi. The third project is investigating the effect of prescribed burns on EM fungi. Research findings show that fire reduced the number of EM roots by approximately eight-fold and that some EM species were harder hit than others. In particular, "Thelephoroid fungi," such as Tomentella sublilacina, a major dominant before the fire, were virtually eliminated by prescribed burning in the forest. How long it will take for them to recover is not known, but the hypothesis is that the major effect will be a greater diversity of fungi in the EM community. By a drastic reduction of the dominants, rarer species that survived the fire will become more common and the community will be much more "even" in its makeup.

Plant Species Diversity and Habitat Relations

An exhaustive search of existing literature and museum collections has been assembled into a computer file that links California's plant species with locations and habitat attributes. This file has potential uses akin to those now available for terrestrial vertebrates through the California Wildlife Habitat Relationships Program (California Department of Fish and Game). The botanical file is currently available on the Internet. Ann Dennis, Ph.D., Research Scientist says, "These habitat-based models will be used to predict plant species present at a landscape scale to test the ability of GIS models to identify species at risk and to predict outcomes of management alternatives."

Other botanical studies are investigating the impacts of livestock activities on plant species composition in meadow ecosystems and the pioneering plant communities in newly disturbed forest sites following logging.

Long-term Soil Productivity Studies

These studies are investigating the effects of timber harvesting practices on soil productivity. Joint aims are to understand how soil disturbance and plant diversity influence basic soil processes governing forest health and net primary productivity, and to test and develop effective ways to monitor soil disturbance to assure protection of soil productivity.

Important findings are that plant response to soil compaction largely depends on soil texture, and that available water-holding capacity can be raised as much as two-thirds by compaction on coarser-textured sands, translating to less water stress and better tree growth," says Robert Powers, Ph.D., Research Scientist.

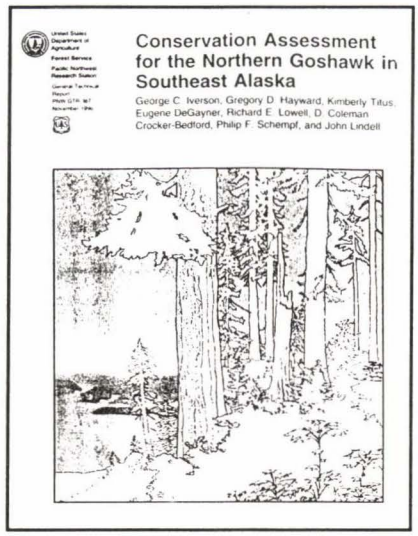
Benefits of this Collaborative Study:

"The study provides a unique opportunity to emphasize collaborative stewardship with major participation between the public and the Forest Service research and administrative branches, "says Ray Porter, Sierra National Forest district ranger. "Such collaboration will enable us to utilize the advantages of adaptive management and change our practices as needed. Benefits from this study will have applicability throughout California."

New from Research

Conservation Status of the Northern Goshawk

This publication examines the conservation status of the northern goshawk in southeast Alaska through developing an understanding of goshawk ecology in relation to past, present, and potential future habitat in the region under the current Tongass Land Management Plan. The assessment indicates that productive old-growth forest lands are an important and selected habitat component of goshawk use patterns with riparian zones and beach fringes receiving preferential use by goshawks. Goshawk habitat capability has declined in southeast Alaska over the last four decades after the predominant clearcut timber harvesting of 1 million or more acres of productive old-growth forest on private, state, and Federal lands; however,


Conservation Assessment for the Northern Goshawk in Southeast Alaska
George C. Iverson, Gregory D. Hayward, Kimberly Titus, Eugene DeGayner, Richard E. Lowell, D. Coleman Crocker-Bedford, Philip F. Schempf, and John Lindell

the goshawk population is likely not in immediate peril. The predicted consequences to goshawks of several alternative habitat management approaches are compared. Managing the land base on a theoretical 300-year rotation is presented as an approach to sustaining goshawks across the Tongass National Forest. Request *Conservation Assessment for the Northern Goshawk in Southeast Alaska*, General Technical Report PNW-387. Supplies are limited.

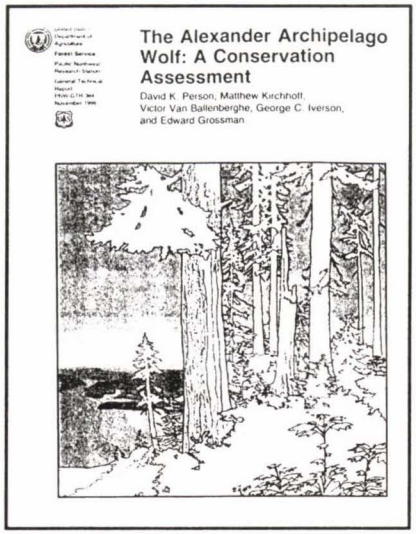
Forest Ecosystem Health in the Southwest

The Rocky Mountain Station has issued a new report that documents an ecological assessment of forest ecosystem health in the Southwest. The assessment focuses at the regional level and mostly pertains to lands administered by the National Forest System. Information is presented for use by forest and district resource managers as well as collaborative partners in the stewardship of Southwestern forests. The report establishes a scientific basis for conducting forest health projects, provides a context for planning ecosystem restoration, and contributes to the understanding of the physical, biological, and human dimensions of these ecosystems. Chapters describe Southwestern forest ecosystems of the past, changes since the Colonial Period, and the implications of those changes for the health of current and future forests.

Opportunities, tools, and research needs for improving long-term sustainability of these forest ecosystems are also identified. For a copy of the report, order *An Assessment of Forest Ecosystem Health in the Southwest*, General Technical Report RM-295, from the Rocky Mountain Research Station - Fort Collins. Supplies are limited.

A Conservation Assessment of the Alexander Archipelago Wolf

There are three primary issues surrounding the conservation of the Alexander Archipelago wolf in southeast Alaska: loss of long-term carrying capacity for deer resulting primarily from extensive timber harvesting, loss of wolves associated with improved human access from roads, and increased legal and illegal hunting and trapping of wolves.

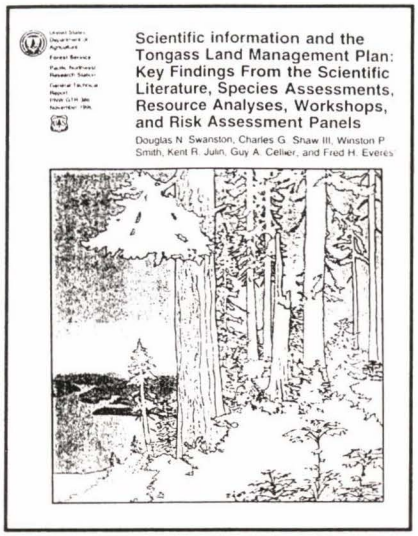

The Alexander Archipelago Wolf: A Conservation Assessment
David K. Person, Matthew Kirchhoff, Victor Van Ballenberghe, George C. Iverson, and Edward Grossman

The continuation of current levels of timber harvesting in southeast Alaska will likely have an adverse impact on some segments of the wolf population. Although short-term regulatory changes may need to be considered to keep wolf harvest at a sustainable level, long-term solutions focus on maintaining or increasing habitat suitable for the Alexander Archipelago wolf in the Tongass National Forest. Request *The Alexander Archipelago Wolf: A Conservation Assessment*, General Technical Report PNW-384. Supplies are limited.

Literature on Wildlife Research in the Madrean Archipelago

A literature search was accomplished on faunal studies conducted from the 1880's to 1994 in southeastern Arizona, southwestern New Mexico, northeastern Sonora, and northwestern Chihuahua, Mexico. The search was conducted at the Science and Engineering Library at the University of Arizona, Tucson, using Quick Search, a computer retrieval system. Abstracts or comments for publications are presented for birds (514), mammals (82), and amphibians and reptiles (21). Information is presented for taxonomic affiliation, geographic distribution, natural history and ecology, conservation and management, and ongoing studies. For a copy of this listing, write the Rocky Mountain Research Station (Fort Collins) and request *Literature on Wildlife Research in the Madrean Archipelago: 1800's - 1994*, General Technical Report RM-290. Supplies are limited.

Key Science Findings from the Tongass Study

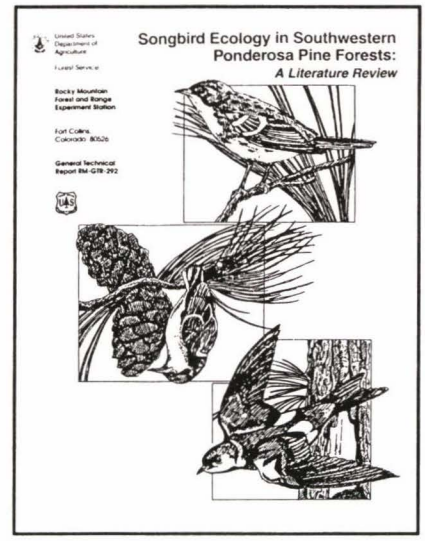

Scientific information and the Tongass Land Management Plan: Key Findings From the Scientific Literature, Species Assessments, Resource Analyses, Workshops, and Risk Assessment Panels
Douglas N. Swanston, Charles G. Shaw III, Winston P. Smith, Kent R. Julin, Guy A. Cellier, and Fred H. Everes

This document highlights key items of information obtained from the published literature and from specific assessments, workshops, resource analyses, and various risk-assessment panels conducted as part of the Tongass land management planning process.

Request *Scientific Information and the Tongass Land Management Plan: Key Findings from the Scientific Literature, Species Assessments, Resource Analyses, Workshops, and Risk Assessment Panels*, General Technical Report PNW-386. Supplies are limited.

Literature Review of Songbirds of Southwestern Ponderosa Pine Forests

This publication reviews and synthesizes the literature about ponderosa pine forests of the Southwest, with emphasis on the biology, ecology, and conservation of songbirds. Critical bird-habitat management issues related to succession, snags, old growth, fire, logging, grazing, recreation, and landscape scale are addressed. Overviews of the ecology, current use, and history of southwestern ponderosa pine forests are also provided. This report is one of the outcomes of the *Silver vs Thomas* court settlement agreement of 1996. It is intended for planners, scientists, and conservationists in solving some of the controversies over managing forests and birds in the Southwest. Copies of the report, *Songbird Ecology in Southwestern Ponderosa Pine Forests: A Literature Review*, are available from the Rocky Mountain Research Station (Fort Collins). Request General Technical Report RM-292. Supplies are limited.

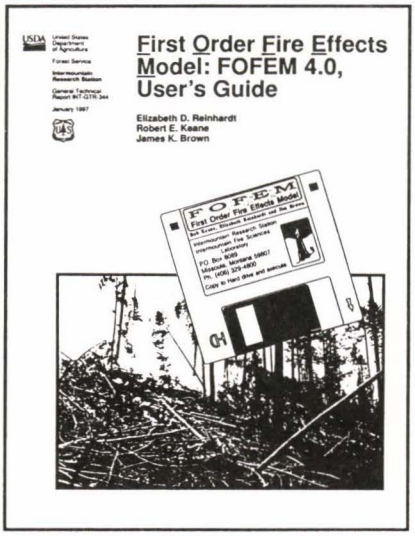


Model Predicts Consequences of Prescribed Fire and Wildfire

Scientists at the Intermountain Fire Sciences Laboratory in Missoula developed a "First Order Fire Effects Model" (FOFEM) to predict the direct consequences of wildland fires.

Fuel consumption, mineral soil exposure, tree mortality, and smoke production are all examples of first order effects FOFEM can predict for fire managers. The software includes a prescribed fire planner to compute the burn conditions necessary to achieve the desired results from a planned management fire.

The model is available for use on the Forest Service's DG computer system or on a PC. The software can be obtained directly from its creators by telephoning them at (406) 329-4800, or writing to them at the Intermountain Fire Sciences Laboratory, P.O. Box 8089, Missoula, MT 59807.


First Order Fire Effects Model: FOFEM 4.0, User's Guide
Elizabeth D. Reinhardt
Robert E. Keane
James K. Brown
FOFEM
First Order Fire Effects Model

For the FOFEM use's guide request *First Order Fire Effects Model: FOFEM 4.0, User's Guide*, General Technical Report INT-344, from the Rocky Mountain Research Station - Ogden. Supplies are limited.

Response of Riparian Systems to Grazing Control and Woody Planting

Scientists from the Boise Forestry Sciences Laboratory studied riparian system response to five different grazing management methods in the Cottonwood Mountains of Oregon and discovered that degraded riparian areas can take longer to recover than many had previously believed.

Conventional wisdom has been that because riparian plants have water available throughout the growing season they can restore health and vigor faster than plants growing on the drier uplands. After measuring change in this riparian system in Pole Creek they concluded that recovery was present, but so slow that it wasn't significant. Recovery of this system will "apparently require many years, probably decades," the researchers concluded.

More encouraging, they found that where cottonwood and willows were artificially planted improvement was significant. During the study an unusual spring flood provided good conditions for natural willow establishment. The naturally established willows did better with light spring grazing than with light fall grazing.

They also studied nesting birds and small mammals. After seven years there were no differences between populations in the different kinds of treatments.

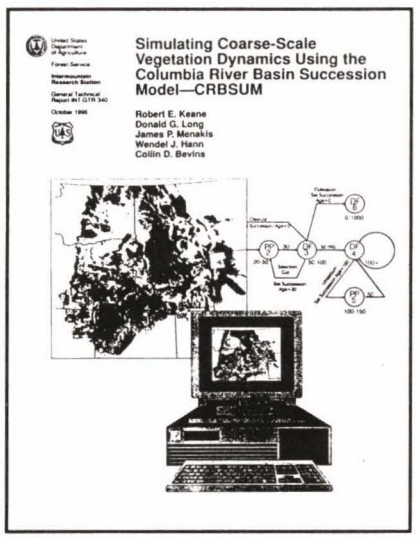
Request *Response of a Depleted Sagebrush Steppe Riparian System to Grazing Control and Woody Plantings*, Research Paper INT-492, from Rocky Mountain Research Station - Ogden. Supplies are limited.

Crown Area Equations for 13 Species of Trees and Shrubs

Growth and yield simulators are valuable tools in forest management decision making. A number of simulators have been developed to meet current management challenges. However, little attention has been given to the impact of brush and non-commercial hardwood trees on stand dynamics. This presents a serious problem when attempting to predict the early stages of stand development where shrubs and sprouting hardwood trees may significantly affect the growth of commercial species. Crown area may be useful as an index of the competition level. One means of estimating crown area is to predict it as a function of variables that may be readily available in a simulator, such as height or diameter. Crown area equations have been developed for 13 species of plants common to southwestern Oregon and northern California. Crown area is expressed as a function of stem basal area and height for each plant. Parameters were estimated for each species individually using weighted nonlinear least square regression. For the purpose of this study, crown area is defined as the area of a vertical projection of the crown to a horizontal plane.

Request *Crown Area Equations for 13 Species of Trees and Shrubs in Northern California and Southwestern Oregon*, Research Paper PSW-227, from the Pacific Southwest Research Station (at its distribution center in Fort Collins, Colorado). Supplies are limited. This publication is also available on the World Wide Web through PSW's home page at: http:// www.pswfs.gov.

Succession Model Simulates Vegetation Dynamics in Columbia Basin


Simulating Coarse-Scale Vegetation Dynamics Using the Columbia River Basin Succession Model—CRBSUM
Robert E. Keane
Donald G. Long
James P. Menakis
Wendel J. Hann
Collin D. Bevins

The Columbia River Basin Succession Model (CRBSUM) simulates broad-scale landscape changes that result from different land management policies. It was designed to compare alternative management strategies on vegetation dynamics at a coarse spatial scale.

CRBSUM simulated landscape changes for four management scenarios in the Interior Columbia River Basin. That simulation showed that under current land management policies, ponderosa pine, western larch, and aspen declined by as much as 30 percent in 50 years. There were also major changes in forest structure — meaning fewer of the open stands of giant pine and larch often referred to as "old growth."

These species and "old growth" type stand structure were historically maintained on the landscape of the Columbia River Basin by much more frequent low-intensity ground fires than have been allowed to burn naturally during this century.

Request *Simulating Coarse-Scale Vegetation Dynamics Using the Columbia River Basin Succession Model—CRBSUM*, General Technical Report INT-340, from the Rocky Mountain Research Station - Ogden. Supplies are limited.

IMPLAN Identifies Rural Development Opportunities

Erv Schuster, Project Leader for the Economic Aspects of Ecosystem Management Research Work Unit, collaborated with Professors David W. Holland, Washington State University, and Hans T. Geier, University of Alaska, to develop the "IMPLAN" computer model to help local community leaders and Forest Service workers to learn what economic development opportunities have the highest probability of success.

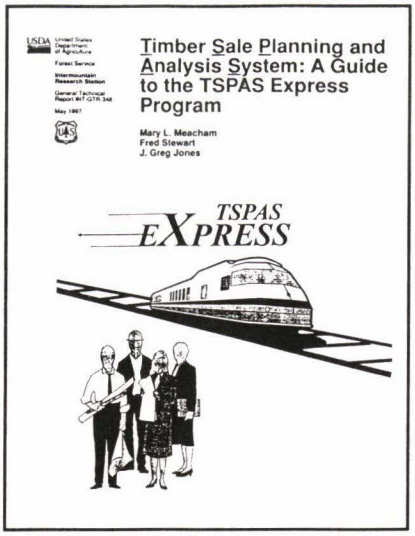
IMPLAN identifies the best development opportunities based on: expanding the export base, substituting local production for imports, and exploiting rural-urban linkages. This report includes a case study completed in Malad, Idaho, a small ranching community. It identified excess demand in the region for a variety of things, including private university schooling, and commodities associated with window blinds, shades, and drapes.

IMPLAN demonstrated usefulness as an economic intelligence tool, but is too complicated for casual analysts, according to the economists who created it. The good news is that there are Forest Service specialists assigned specifically to the task who can be asked to work with local community leaders and local forest officers.

Request *Using IMPLAN to Identify Rural Development Opportunities,* General Technical Report INT-350, from the Rocky Mountain Research Station - Ogden. Supplies are limited.

TSPAS_X Designs and Analyzes Timber Sales

Mary Meacham and Greg Jones, from the Missoula Forestry Sciences Laboratory, collaborated with Forest Economist Fred Stewart, of the Lolo National Forest, to develop an interactive computer model, TSPAS Express, that defines and analyzes timber sales.



The program is designed to produce two reports that document economic analysis for the NEPA process. The second of the those reports shows all of the user-input data. This allows reviewers of NEPA documents to see what went into the economic analysis.

TSPAS_X operates on the Forest Service's Data General computer system.

Request *Timber Sale Planning and Analysis System: A Guide to the TSPAS Express Program,* General Technical Report INT-348, from the Rocky Mountain Research Station - Ogden. Supplies are limited.

Campsite Impacts in Four South-Central State's Wildernesses

David Cole of the Aldo Leopold Wilderness Research Institute in Missoula, MT, worked with Professors Douglas McEwen of Southern Illinois University, Carbondale, and Mark Simon of New York State University, Potsdam, to study campsite impacts in Wildernesses in Illinois, Missouri, and Arkansas. They learned that campsite density caused more problems than impact on individual campsites, concluding that management should focus on limiting the number of campsites to reduce wilderness pacts in this region.

The authors offer management strategies, monitoring procedures, and educational programs to aid wilderness managers.

Request *Campsite Impacts in Four Wildernesses in the South-Central United States,* Research Paper INT-490, from the Rocky Mountain Research Station - Ogden. Supplies are limited.

Case Study of Wildfire that Ran 490 Feet Per Minute

Bret Butler from the Intermountain Fire Sciences Laboratory in Missoula and Timothy Reynolds from the Environmental Science and Research Foundation in Idaho Falls studied the Butte City Fire that started on July 1, 1994 on land that is part of the Idaho National Engineering Laboratory located on the sagebrush dominated Snake River Plains. They discovered information valuable for both firefighter training and validating fire behavior models.

The fire provided an unusually good opportunity for a case study because The National Oceanic and Atmospheric Administration's Air Resources Laboratory had 31 meteorological monitoring stations in place on the site before the fire was ignited by a burning flat tire from a horse trailer. In addition, because detailed biological studies had already been conducted on the site, the researchers had good data on the plant communities and fuels that the fire burned in.

The Butte City fire burned 20,500 acres in 6.5 hours with flame lengths up to 40 feet, constituting extreme fire behavior. Given what they've learned about fires in this area, scientists predict that that the extreme fire behavior observed with this fire can be seen again during any fire season.

Request *Wildfire Case Study: Butte City Fire, Southeastern Idaho, July, 1994,* General Technical Report INT-351, from the Rocky Mountain Research Station - Ogden. Supplies are limited.

To order any of the publications listed in this issue of Forestry Research West, use the order cards below. All cards require postage. Please remember to use your Zip Code on the return address.

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2) *Literature on Wildlife Research in the Madrean Archipelago: 1800's - 1994,* General Technical Report RM-290.

3) *An Assessment of Forest Ecosystem Health in the Southwest,* General Technical Report RM-295.

4) *Songbird Ecology in Southwestern Ponderosa Pine Forests: A Literature Review,* General Technical Report RM-292.

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